STABILITY AND RECOMMENDED STORAGE PRACTICES FOR NEW IMAGE MEDIA

by

Alan Calmes

Preservation Officer

National Archives and Records Administration

Washington, D.C.

DEVELOPMENT OF IMAGE MEDIA

The first medium used to record an image was a cave wall. Parchment and paper followed much later. Paper as a carrier of image data has held up well during the past 500 years. Some papers have lasted longer than others as a result of chemical composition and conditions of storage and usage. Photographic plates and films emerged in the 19th Century.

The requirements of a flexible base material for motion picture film brought about the use of cellulose nitrate film. Silver halide suspended in gelatin proved to be a stable recording material for photography. Cellulose nitrate gave way to cellulose acetate by mid-20th Century and color dyes replaced silver halide in many films. By 1990, polyester was the preferred film base for images that had to have a long life. Image stability of photographic film continues to be improved. If processed and stored correctly, a photographic film image should last 500 years.

Recording of images by signal processing evolved from sound recording technology. At first, sound recordings were sound-waves reproduced by analogous physical bumps in a spiral groove. The vibrations produced on a stylus, when dragged across the bumps, simulated the original sound. Later, sound recordings were magnetic signals in metal particles on a thin strip of film. The frequency modulations of the magnetized particles produced electronic signals which could activate a loud-speaker magnet and thus replicate the original sound. Magnetic tape evolved from this technology.

Gamma ferric oxide bound in polyurethane painted on polyester proved to be an effective system for the manufacturing of magnetic tape.

Video recording technology evolved out of the sound recording magnetic tape technology. The magnetic signals represented image information as well as sound. It took many tracks at first to include all the data necessary to reconstruct moving images. In the late 1950s, the first video tapes were 2 inches wide. Eventually, the format was reduced to 1/2 inch wide tape.

During the past ten years the use of video tapes has grown exponentially. The U.S. Federal Government's expenditures on video productions are now greater than on motion picture productions. The huge consumer market for VCRs has given rise to the widespread use of home video cassettes for television recording and rental tape libraries. Low-cost, light-weight video cameras are now replacing home movie film cameras. Magnetic tape is replacing motion picture film as the preservation medium for memorable events, such as weddings and birthdays. Users of video tape, however, are not being warned that video images may not last as long as those on motion picture film and that neither new machines necessary to read the old tapes nor spare parts for old machines will be available 25 years from now.

Computer tape copied the manufacturing methods developed for sound recording and video tapes. One-half inch wide tape became the standard for computer tape early in its history and remains the standard width of computer tape. As in sound and video, cartridge computer tape systems are displacing open-reel systems.

Master sound recording platters were acetate coated glass, metal and vinyl disks. Mass produced, stamped-out, all vinyl records dominated the commercial market for about 5 decades. Both video and computer technologies have copied the disk concept of sound recordings.

Except for the analog video laser disk, sound recording set the trend for optical disks by the highly successful digital compact disk (CD) introduced in the early 1980s. Both the CD and the video laser disk represent a mastering technology in which the information is stamped into the surface of the disk. The compact disk/read only memory (CD/ROM) is similar to the digital CD. The write once, read many times (WORM) disk evolved in the 1980s and made use of rare-earth compounds, such as tellurium, on a polycarbonate substrate and sealed air-tight, either by a glass sandwich or by a layer of acrylic or epoxy. Recently, optical and magnetic technologies have merged into the optical/magnetic disks.

The trend in information storage devices has been for more compactness, greater access speed and lower cost. Whereas these goals are good for current operations, they may be contrary to the long range goals of an archives. More compaction means that more information will be at risk in a smaller unit. Greater access speed raises the operating cost of equipment and implies random storage and access methodologies. In the long run it may be more difficult or impossible to retrieve information stored randomly. Lower cost now often turns out to be higher cost later.

ARCHIVAL EXPERIENCES WITH MEDIA

Records are usually 20-30 years old by the time they reach the care of an archivist. Before records are transferred to an archives, they may have been stored in harsh environmental conditions and subjected to rough handling. Archival materials made of plastic often arrive in need of special attention. For example, cellulose nitrate film may arrive in an advanced state of deterioration and be highly flammable and in need of special handling, packaging and storage; Dictaphone[tm] belts may arrive cracked and broken. An archivist needs to know the aging characteristics of plastics, conservation measures suitable for plastics, and copying techniques.

Especially vulnerable are non-paper records, such as motion pictures, video recordings, photographs, sound recordings, and computer data. Some of the most important historical information of the second half of the 20th century will require special conservation and duplication efforts to preserve the memory of the nation. A partial list of important events recorded on plastics would include: political debates and presidential addresses and news conferences on radio and television; satellite mapping and environmental observations; and motion pictures of historic events. An example of valuable information on a plastic medium is the sound-recording of the Nuremberg Trials which were recorded on a long loop of cellulose acetate film. The embossed grooves and bumps have nearly disappeared as the plastic material has gradually returned to its pre-embossed smooth state. A special machine had to be built with a special tracking stylus to play the loop.

Until the late 1950s, cellulose acetate films were used as a very thin base material for sound recording tape and for some early video and computer tape. With age--accelerated by elevated temperatures and high relative humidities--thin cellulose acetate tape becomes brittle and will break easily. Brittleness is an inevitable condition. Solvents used during the manufacturing process to disperse the oil-based plasticizers will ooze out onto the surface of the tape in the form of white droplets which look like powder. To complicate matters, a recording layer, such as one composed of iron oxides dispersed in polyurethane, will have characteristics of degradation different from that of the base material.

A break in cellulose acetate magnetic tape is usually clean. It can be spliced back together again with little loss of information for an analog sound or video recording. This is different from polyester-based magnetic tapes which stretch considerably before breaking.

Poly(ethylene terephthalate), commonly known as "polyester" or "PET" entered upon the scene in the late 1950s. Because of its strength, even in a very thin film, it was used as the substrate for all computer and video tapes. Soon thereafter, polyester replaced cellulose acetate as the base material for sound recording tape. The switch from cellulose acetate to polyester based photographic film has been very slow. The demand for a strong, long lasting microfilm brought about the use of polyester for microfilm in the 1980s, but it coexisted with cellulose triacetate based microfilm.

With the right combination of conditions, water molecules can break the bonds between monomers of polyester and in the process acids are created that in turn break more bonds. This process is called acid hydrolysis and, once started, degradation is auto-catalytic. Hydrolysis can be initiated by acids present in polluted air or left over from the manufacturing process. Oxides of nitrogen from automobile exhaust form acids in the atmosphere which can accelerate the degradation process of plastics. Exclusion of water from the air, that is, maintaining a low relative humidity, is an effective strategy to prevent hydrolysis. Using scrubbing systems to remove pollutant gasses from the air is another. The lower the temperature the slower the rate of chemical reactions. To slow down degradation, carbodiimides are added to react with acids and anti-oxidants to react with oxygen; however, the additives will be either used up, oozed out, or evaporated out of the plastic.

Polyester is bi-axially oriented or "balanced". Cellulose acetate is often uni-axially stretched. Due to its limberness, polyester tape is more difficult to handle than cellulose acetate tape. Polyester tends to respond to tensions. For example, it will curl under tension. These characteristics vary with the thickness of the tape. The much thicker film for photographic film will demonstrate different properties, such as springiness rather than limberness. Polyester has what is called "plastic memory", and trys to go back to its unstretched state.

With emphasis on compaction, polyester-based computer magnetic tape has become extremely thin, but there is, concomitantly, a greater degree of risk of loss of information, as a small amount of stretching or some other dimensional change can cause the loss of data.

The advantages of video tape have forced producers to abandon the use of motion picture film for the instant playback capability, easy editing, and low-cost of video production. Users like other advantages: fast forward, stop, reverse, quick and easy to play, no need for screen and projector, compact, easy to mail, familiar TV format. However, there are long-term disadvantages that must be recognized. Video tape is not a long-lasting medium, each time it is played it loses some of the picture signal. After about 100 plays the degradation is noticeable. The flexibility of the material will gradually decrease as the plasticizers slowly evaporate. Fluctuating high temperatures and relative humidities further exacerbate the degradation process by causing embrittlement of the recording layer.

Polymethyl methacrylate (PMMA) has been used in a compressed form for compact disks and CD-ROM disks. The digital information was pressed into the acrylic. Often it was also coated with epoxy. Consumers began to note the failure of this product in the late 1980s. Beginning in 1990, CDs and CD-ROMs were beginning to be made from polycarbonate, which is tougher and more resistant to change than PMMA.

There are two main areas of concern regarding video recordings: the magnetic tape and the machine to read the tape. The tape consists of a base of polyethylene terephthalate, commonly called "polyester," and a recording layer of polyester polyurethane, referred to here to avoid confusion as "polyurethane." Some tapes are also back-coated. Polyester is dimensionally stable, which is important for consistent tracking, strong, and long-lasting. Polyurathane is durable, which is important for resisting wear by contact with the video-machine reading head. The polyurethane layer is called the "binder" for it holds in place the ferromagnetic particles which hold the signal which is the source of information to the machine for generating a picture. Lubricants also are placed in the binder to prevent friction. The back-coating, usually of polyurethane, prevents static. The chemical formulations for each layer vary from one manufacturer to the next; they are industrial secrets. Prediction of the behavior of a particular tape is difficult since there will be many unknowns about the chemical composition of that tape. Life-expectancy, therefore, will always be uncertain given these unknowns. Accelerated aging of tape samples have been carried out by the U.S. National Institute of Standards and Technology (NIST, formerly, National Bureau of Standards) for the National Archives of the U.S. NIST estimated the useful lifetime of digital computer tapes to be about 20 years when maintained in ambient environmental conditions. Video tapes and computer tapes are similar magnetic tapes.[3]

During the tape manufacturing process, despite industrial quality control procedures, some tapes will be flawed. Flaws can lead to difficulties, such as drop-outs. Some off-brand tapes may be manufactured with recycled polyester; some even may be reused tapes. It is a challenge to the professional and consumer alike to judge which tape is best. The U.S. Consumer Reports have evaluated tapes for dropouts, noise, dynamic range, and bandwidth, but not for durability and longevity. There are differences in the performance of tapes and certainly there are differences in longevity. NIST plans to develop a test for evaluating tape longevity. Currently, however, it is a matter of "pot luck." Higher quality tape may give better performance but not better life-expectancy.

Images recorded on a video tape consist of machine-readable information. That is, it takes a machine to interpret the magnetic signals on the tape. One can not simply hold the tape up to a light and see the images. A particular video tape format requires a particular machine for reading. Since 1956 over 30 different formats have been used, each requiring a special machine. Most of these have been professional, educational, and industrial formats. There are only 3 consumer formats: Beta[tm], VHS[tm], and 8mm. (The latter requires the use of metal particle tape, characteristics of which are little known, except that its recording layer is susceptible to oxidation in presence of water vapor and must be coated with another protective layer.)

The distance between the video head of the recorder and the tape is only about .02 mils. A finger print can leave as much as a .6 mils film on the tape, which drives the reading head away from the tape, resulting in a loss of signal. Dust particles are huge in comparison with the reading gap and may cause gouging into the surface of the tape. An old tape will have a layer of lubricant and products of degradation exuded onto its surface. The material will collect on the reading head and, if not removed, the condition will cause the head to gouge into the tape; this is called a "head crash." A tape having debris on its surface should be gently whipped clean with a non-woven paper before use. It is important to wind the tape evenly, otherwise edges will become damaged and a tape with damaged edges will not align properly across the reading head.

Professionally produced magnetic tape recordings may have a life-expectancy of 15-30 years under controlled storage conditions, careful handling, and infrequent playback. The tape should be re-tensioned before playback and re-wound evenly. The tape head and tape must be clean. Under adverse conditions, the life-expectancy will be less. Normal household environment is likely to have high and fluctuating relative humidity, which is detrimental to tape, resulting in embrittlement of the tape. If care is not taken to wind the tape evenly, to keep the reading head clean and to wipe away residues from tape surfaces, the tape will become damaged and the system as a whole will become degraded: a damaged tape will damage the machine and a damaged machine in turn will damage tapes. It is important to use undamaged tape. Cut off wrinkled or folded ends.

Rapid changes in technology during the 20th Century have compounded the problems concerning the maintenance of information in other than human-readable form. For example, from the 1930s through the 1950s, sound-recorded dictation was kept on a cellulose acetate belt, sometimes referred to as a "Dictabelt"[tm] from a "Dictaphone."[tm] At first, the sound frequencies were embossed mechanically into the surface of the cellulose acetate belt; later, the sound was recorded magnetically onto the surface of the belt. A simple stylus can translate embossed sounds into an amplifier, like that used for vinyl disk players. To play the magnetically recorded dictation on a belt, it will be necessary to obtain the same type of machine as that used to produce the recording, or research will be necessary to determine the appropriate size of stylus and use an appropriate transducer and amplifier and play the recording at the correct speed.

Video pictures are machine dependent; that is, one must maintain compatible playback equipment or periodically copy the images to a new format capable of being played on currently available equipment. With analog recordings, there is a subsequent loss of quality with each generation.

The biggest problem with the preservation of video recordings is not so much the life-expectancy of the tape but the obsolescence of the machinery necessary to read the tape. Once a format has been abandoned, machinery will rapidly become scarce and even spare parts will become difficult to find after a few years. It may seem unreasonable to recommend the use of a professional format which is likely to become obsolete in a few years and not a consumer format which may continue in use longer, but the cassette tape systems for home Beta™ and VHS™ are not as reliable as the tape systems used in professional models. Consumer cassettes often use thin tape and their housings prevent observation of tape-wind tension and distribution. With consumer video products, it is difficult to control the tape guide, speed, and tension. A professional recorder/player, on the other hand, is designed specifically to provide for control over these variables. A professional video recorder, however, costs about 100 times more than a consumer VCR.

The pace of technological change has quickened during the 20th Century. Vinyl records have been in use for nearly 100 years, analog sound recordings on magnetic tape for 50, digital recording for 30, and format changes are now occurring nearly every decade. Plastics have played a role in the quickening of change by providing an infinite variety of new materials for adaptation. For example, computer information systems are constantly being upgraded with increased information density and reading speed, such as dye-polymers used in some optical-magnetic recording systems to provide very high density storage and fast random access.

Will standards simplify matters? Standards will not prevent the proliferation of incompatible formats. The many formats created during the past 30 years have been produced according to standards. Manufacturers are not likely to develop equipment and formats especially for archival purposes. Archives will have to live with what is produced for the market-place. To guarantee the preservation of video images, archives should copy the machine-readable video recording onto human-readable photographic film. Motion picture film devices are much simpler than video recorders. In 50 years, for example, it will be a simple matter for an archivist to view any motion picture film, but extremely difficult to view moving images from a video recording. No matter how many video machines of a given type are put on the market, after 10 years or so it will be virtually impossible to find workable spare parts. The manufacturer will not stockpile them; those out in service have a meantime to failure of only about 2000 hours of playing time. The current trend is away from long lasting stability of video images and toward smaller cameras and greater compaction. The materials are not designed for preservation. Add to this the trend toward high definition television and the picture gets even more complicated.

STORAGE PRACTICES

An image is a reproduction of a likeness, such as the graphic representation of land found on maps, of people and places in drawings and paintings, and the identical scenes in photographs, and motion pictures.

Images on paper, such as maps and drawings, tend to be oversized and can be damaged easily by handling. Physical damage to large pieces of paper is common. Most architectural and engineering firms store architectural and engineering drawings rolled and placed in long metal cylinders. Chemically, paper is subject to inherent weaknesses, such as acids. Mold will attack paper if the paper becomes damp. Paper as an image carrier loses its long term usefulness as the size of the paper increases.

Miniaturization of images solved the problem of handling and storing oversized sheets of paper. Film images have been in use for many decades. Aperture cards proved to be a convenient storage system for images of architectural and engineering drawings. There are long term storage problems with aperture cards, however, for they are generally on acidic card stock and the adhesives used to hold the film in the slot will cause degradation of the film in course of time.

The need to periodically duplicate information extends to all types formats: sound recordings, video recordings, motion picture film, and computer tapes. How often this is done depends on how the medium is stored and handled, and on the characteristics of the plastics used.

Originally, almost all black and white 35mm motion picture film was on cellulose nitrate film. It was used exclusively for studio work from the 1920s to the 1950s. Cellulose nitrate was not used for color film, or for 16 mm and 8mm home movie film.

When ignited, cellulose nitrate burns very rapidly. Nitrate film decomposes with the emission of oxides of nitrogen. The reactions are highly exothermic and are responsible for the self-ignition of cellulose nitrate. Despite the hazards, commercial film makers preferred cellulose nitrate film over cellulose acetate safety film because it was easy to handle and produced a very clear, sharp image when projected. By 1950, however, after many theater fires, fire codes mandated the use of safety film. During the past 10 years, after several devastating and dangerous cellulose nitrate film vault explosions and fires, archives and libraries have copied most cellulose nitrate film images onto safety film (a cellulose acetate or polyester film) and disposed of the cellulose nitrate film. There remains, however, some spliced-in cellulose nitrate film within reels of safety film.

Nitrate-based film stock can be identified by feel; it is softer and more supple than cellulose acetate or polyester film. When degrading, its appearance may be deceiving. It is safer to have a laboratory test it.

The aging of cellulose nitrate is characterized by rapid change once the deterioration process begins. Prior to the onset of deterioration, there is no serious shrinkage of the material, image quality is good, and the images can be copied easily. The kinetics of the reaction are such that there appears to be virtually no intermediate stage between the time when the film is in good condition and the time when it is obviously deteriorated. Archivists have seen reels of cellulose nitrate film change from excellent to extremely poor condition in 2 months. When it deteriorates, cellulose nitrate film produces sticky-brownish-powdery-fibrous globs.

Out-gasses from deteriorating cellulose nitrate film can initiate the process of deterioration in neighboring films of all types. Chemically, cellulose nitrate, upon decomposition, produces its own oxidizer, and, therefore, once the chemical bonds begin to break down, a rapid autocatalytic reaction sets in. The reaction produces its own heat which accelerates the initial break down and the process can be so fast as to produce fire and, if film is tightly compacted, an explosion. Once degradation of a cellulose nitrate film has been spotted, the archivist must move quickly to copy the images onto safety film and to dispose of the cellulose nitrate film. The continued usefulness of a reel of cellulose nitrate film depends upon good environmental conditions, such as clean, cool, and dry air.

The same general mechanism of deterioration of cellulose nitrate occurs in a similar way in other cellulose esters. The same acid hydrolysis occurs in all cellulose materials, but the other esters produce only an acid which catalyzes further acid hydrolysis, not an oxidizer like nitrogen dioxide in the case of cellulose nitrate. The degradation process of cellulose acetate film takes longer than that of cellulose nitrate film, but once started, the autocatalytic chemical reaction cannot be stopped. The result of the self-destruction of cellulose acetate film is somewhat different from cellulose nitrate film, in that an intermediate stage of deterioration between a good condition and a powdery condition can be seen. Acetic acid, a product of cellulose acetate degradation, can be detected by its vinegar odor. The presence of acidic gases and particles found in polluted air will initiate the degradation process of cellulose acetate film. Unlike nitrate film, however, the image layer is not chemically affected by the by-products of the decomposition of the acetate substrate.

The first safety-based films were cellulose mono-acetate and cellulose diacetate. The term "safety-base" was used because acetate films do not burn easily. By the the 1970s, triacetate began to replace diacetate as the favored substrate for film.

Researchers at the Image Permanence Institute in Rochester, N.Y., are finding little difference between the degradation processes of cellulose diacetate film and cellulose triacetate film. One is not necessarily more stable than the other. The process, however, might take longer with a triacetate than with a diacetate.

The long, intermediate stage of deterioration of cellulose acetate film is characterized by shrinkage. When the cellulose acetate film base shrinks, the emulsion layer on top, which does not shrink, is deformed into a mass of wrinkles. Since the image is within the emulsion layer, the image becomes illegible, unless there is a way to copy or transfer the emulsion layer before the wrinkling obscures the image. The choices are to copy the image before this occurs or to laboriously remove and re-apply the image layer after it occurs. The greater the shrinkage, the more difficult it is to recover the information. When motion picture film shrinks, the sprocket holes are no longer in the right place, making the copying process, necessary to save the images, difficult and expensive. The shrinkage will be uneven; consequently, engineered sprockets with a different spacing may not provide a solution.

Plastic containers have significant advantages over metal cans and cardboard paper boxes. They do not corrode, are light weight, and unaffected by humidity or water. Polypropylene motion picture containers are being used in some archives. There should not be any solvents or plasticizers in polyolefins. However, colorants may come to the surface and cause a problem and flame-retardants required by fire codes may slowly, even at normal temperatures, emit small quantities of reactive materials, which might affect the contents of the container.

Plastic cartridges can warp and cause magnetic tape to mis-track when read and to mis-align when rewound. In the latter case the edges of the tape may rub against the sides of the container. Plastic pressure pads in magnetic tape cartridges have been known to crumble after a few years. The pieces of pad can damage the reading machine and get between the layers of tape, causing the tape to be wound unevenly.

Because magnetic tape is thin and will sag against the flange when stored horizontally, magnetic tape should be stored vertically, suspended on a hub; otherwise, an unevenly wound tape will result in having its outlying tape-edges folded under by the weight of the rest of the tape. Motion picture film is thicker and stiffer than magnetic tape and is stored horizontally without flanges with the film resting on the surface of the container. The film must be wound evenly and snugly. Instead of metal, hubs and flanges are sometimes made of polystyrene. In special cases glass has been used for flanges. Plastic is substantially cheaper and lighter than metal or glass; thus, we can expect to see more plastic.

Plastics can hold a static electric charge and can release sparks and electromagnetic radiation. Static is a problem for the microelectronics of some machines. Some manufacturers try to mitigate the problem of static electricity by adding an anti-static layer to the back of tape or placing an anti-static additive directly into the plastic. Tapes coming out of long term storage should be equilibrated at greater than 30 percent relative humidity to dissipate the electrical charge and ground metal reels. Static electricity also attracts dust and grit that must be kept away from magnetic tape or disk surfaces to prevent a reading head from bumping into them. Note that polystyrene, the plastic material used for tape flanges, can also collect a static charge. Dust and grit are also undesirable on film since they scatter light, cast shadows and scratch the emulsion. Also, it is undesirable to attract dust and grit at the time of polyester encapsulation of documents.

During the past ten years the use of video tapes has grown exponentially. The U.S. Federal Government's expenditures on video productions are now greater than on motion picture productions. The huge consumer market for VCRs has given rise to the widespread use of home video cassettes for television recording and rental tape libraries. Low-cost, light-weight video cameras are now replacing home movie film cameras. Magnetic tape is replacing motion picture film as the preservation medium for memorable events, such as weddings and birthdays. Users of video tape, however, are not being warned that video images may not last as long as those on motion picture film and that neither new machines necessary to read the old tapes nor spare parts for old machines will be available 25 years from now.

It is essential that the tape and recording mechanism operate in perfect harmony. Alignment must be correct or the recording will be non-standard and when played will mis-track and produce a poor quality picture.

The following procedures will help produce a longer-lasting video recording. Re-wind the tape before recording to re-tension the tape evenly. Record at fastest speed to spread out the packing density and thereby reduce the risk of loss of information. Regular monitoring, cleaning, and servicing of the equipment is necessary. During recording, the tape and the machine should be equilibrated to the same environmental conditions; a cold tape in a warm machine may produce mis-alignment. It is very important that the tape and the machine be clean and the air around them clean as well.

Most importantly, relative humidity should be kept stable and low, the lower the better, but not below 30%RH, and never above 55%RH. Once a relative humidity level has been chosen, say 40%RH, then it should not very more than an average of plus/minus 5%RH during a 24 hour period. Tapes may be conditioned to 40%RH at storage temperature and sealed in foil-lined bags, in which case only the temperature need be maintained exactly. Temperature is equally important and should be stable and as low as possible, but not below freezing and never above 23 ^{o}C (73 ^{o}F). Minor fluctuations such as an average plus/minus 2.8 ^{o}C (5 ^{o}F) are permitted during a 24 hour period. The tape and the machine should be conditioned to the same environment. The air must be clean and free of pollutant gases, especially those from oil-based paints, insecticides, perfumes, cigarettes, and chemical cleaners. There should be no dust or smoke present in the storage or operating environment. Note: these environmental conditions are not generally found in the home and rarely found in libraries.

Even short term inappropriate environmental conditions can contribute to the degradation of the tape and its magnetic signal. One must avoid subjecting tapes to shocks of rapid and extreme temperature/relative humidity changes, especially upon reading the tape on a reader. Before using tapes that have been shipped, re-equilibrate them 24-48 in the same environment as the video machine.

The following list of do's and don'ts apply to the creation and storage of video recordings: Do not use high compaction systems, because hardware precision increases with compaction, as the tape tracks are very close together. Only use brand-name tapes. Avoid extended play, thin tapes. Always use a new tape. Use a tape-certifying machine to weed out flawed tapes. Record at standard speed or fastest speed available. Rewind at slow speed before storage and before playing. Rewind in the same environment as the storage environment before storage and same environment as operating equipment before recording or playing. Tension must not be too loose nor too tight. Monitor the condition of tapes: look for edge damage and residues on surface. Recopy when deterioration is noted and/or when the format is obsolete. Differentiate between the master copy and use/distribution copies. Produce the master copy under controlled operations and environment. Designate a repository to be responsible for the preservation of the master copy. Currently, the creators of video productions rarely maintain masters. It is difficult to know who is responsible for the preservation of a video production. For example, the only known repository for popular music videos is the Museum of Modern Art in New York. Only use the master to make distribution copies; ideally, this should be done rarely. A tape that has been subjected to uncontrolled use and storage cannot be expected to last a long time. Rewind the master on slow speed every few years. A special re-wind machine should be used. For permanent (100+ years) preservation of images, copy the video images to black and white motion picture film. Copy the video images to color film for long-term (50+ years) preservation of color images. Store film in cold storage for even longer preservation.

The new digital formats can be used for indefinite, continued copying of images without degradation of image quality. Copy analog video to digital video and thereafter copy the digital tape periodically to keep up with changing technology and to avoid being left with a tape that can not be read by existing machines.

Soon, most video cameras will use digital recording systems. Preservation of digital video pictures will become an activity associated with the more complex world of the preservation of computer data and the use of computer storage devices. To further complicate the array of trade-offs, new tape formulations with unknown aging characteristics, such as metal particle tape, are likely to replace the more familiar gamma ferric oxide magnetic tape and new formats for high definition television will complicate matters more.

Storage of information on optical digital disk is likely to be for direct access purposes rather than for extended term storage. Archivists are looking at tape back-up systems as the "archival copy" of information stored on optical disk. Since the back-up requires high density, hybrid systems, such as the adaptation of video formats for mass digital data storage are being utilized. These hybrid systems have unique coding schemes and are not compatible with other machines.

In the future, an archivist's attention will focus on the head tape interface of high density magnetic data storage systems. To read data 20 years or more from now, archivists will have to have the appropriate working tape head interface. The problem is comparable to that of having a working stylus for an old dictation belt, but much more complex and much smaller in size and dependent on microelectronics.